Analysis of the variations in balance and proprioception in relation to the practice of surfing: a pilot study

Carla Gimeno[1], Gonzalo Mariscal[1,2], Joaquín Alfonso[1], Carlos Barrios[1]

[1]Instituto de Investigación en Enfermedades Musculo-Esqueléticas. Universidad Católica de Valencia. Valencia. [2]Departamento de Cirugía Ortopédica y Traumatología. Hospital Universitario y Politécnico La Fe. Valencia.

doi: 10.18176/archmeddeporte.00072

Received: 28/10/2021
Accepted: 26/11/2021

Key words:
Surf. Balance. Water Sports. Proprioception. Postural balance.

Summary

Introduction: Surfing is a sport that requires a level of balance since it takes place in a changing environment. Hypothesis: Exercises that value proprioception are expected to show better results in advanced surfers than in beginners and non-surfers.
Objective: To assess how the practice of surfing intervenes in proprioception by comparing beginners and advanced surfers with each other, and with non-surfers.
Material and method: A sample of 30 participants, 10 surf beginners, 10 advanced surfers and 10 non-surfers, was tested in Valencia ("Mediterranean Surf School") and Zarautz ("ESSUS"). A questionnaire and 6 tests were performed evaluating: the static balance, Balance Error Scoring System (BESS) and dynamic, Y-Balance Test (YBT); back flexibility, Schober's Modified-modified-Test, and lumbar strength and resistance, Biering-Sorensen test (BSTT); perceived effort, the Borg scale; and quadriceps strength, ChronoJump® kit.
Results: In the BESS test there were significant differences (p = 0.02) in the total result of errors on unstable surface, being lower in advanced surfers than in non-surfers. In the total scores of the YBT, in the Schober test and in the BSTT, we did not obtain differences. Surfers improved in quadriceps isometric strength and on the Borg test (p = 0.008).
Conclusions: No differences in balance strategies were obtained. We observed improvement of the static balance in advanced surfers compared to non-surfers, when the demand for balance is at its highest.

Análisis de las variaciones del equilibrio y propiocepción en relación con la práctica del surf: estudio piloto

Palabras clave:
Surf. Equilibrio. Deportes acuáticos. Propiocepción. Equilibrio postural

Resumen

Introducción: El surf es un deporte que requiere un nivel de equilibrio ya que se desarrolla en un entorno cambiante. Hipótesis: Se espera que los ejercicios que valoran la propiocepción muestren mejores resultados en surfistas avanzados que en principiantes y no surfistas.
Objetivo: Evaluar cómo la práctica del surf interviene en la propiocepción comparando a los surfistas principiantes y avanzados entre sí, y con los no surfistas.
Material y método: Una muestra de 30 participantes, 10 surfistas principiantes, 10 surfistas avanzados y 10 no surfistas, fue analizada en Valencia ("Mediterranean Surf School") y Zarautz ("ESSUS"). Se realizó un cuestionario y 6 pruebas que evaluaban: el equilibrio estático, Balance Error Scoring System (BESS) y el dinámico, Y-Balance Test (YBT); la flexibilidad de la espalda, Schober's Modified-modified-Test, y la fuerza y resistencia lumbar, Biering-Sorensen test (BSTT); el esfuerzo percibido, la escala de Borg; y la fuerza del cuádriceps, ChronoJump® kit.
Resultados: En el test BESS hubo diferencias significativas (p = 0,02) en el resultado total de errores en superficie inestable, siendo menor en los surfistas avanzados que en los no surfistas. En las puntuaciones totales del YBT, en el test de Schober y en el BSTT, no se obtuvieron diferencias. Los surfistas mejoraron en la fuerza isométrica del cuádriceps y en el test de Borg (p = 0,008).
Conclusiones: No se obtuvieron diferencias en las estrategias de equilibrio. Observamos una mejora del equilibrio estático en los surfistas avanzados en comparación con los no surfistas, cuando la demanda de equilibrio es máxima.

Correspondence: Gonzalo Mariscal
E-mail: Gonzalo.mariscal@mail.ucv.es

Best Paper Honourable Mention Award at the Congress

Introduction

As a sport, surfing is currently experiencing a boom, attracting an increasing number of enthusiasts. Balance is an essential performance quality of this sport, while muscle strength, cardiorespiratory endurance and aerobic and anaerobic power also play an important part[1,2]. However, the fact that it is necessary to stand up on an unstable surface makes the athlete's balance the fundamental basis for practising surfing. Furthermore, unlike other sports, external factors come into play, given that it is performed in an ever changing environment that requires surfers to continuously adapt their balance to the conditions of the moment[3].

Balance is fundamental to what are considered to be the Basic Activities of Daily Living (BADL), for both maintaining one's position and also for performing a daily movement or learning new, more specific movements. This requires the interaction of different systems such as the sensitive vestibular, visual and proprioceptive system, the central nervous system and the musculoskeletal system[4,5].

Balance is directly related to proprioception. This system in turn is supported by muscles, joints and cutaneous receptors that incorporate information on the status of the effector system (force, tension, orientation, position of limbs) and environmental information (distribution of pressure, contact with the surface and others)[4]. This information is transmitted to the brain where it is processed, subsequently preparing and sending position adjustment responses[4,6].

These systems, which are essential for balance, provide us with somatosensory information. Damage to these systems, which occurs in certain pathologies, represents a difficulty for the BADL. Therefore, a joint injury will affect this proprioceptive system and, consequently, this will lead to an alteration of the somatosensory information. These alterations on the system may subsequently make an individual prone to further injury[6]. In the same way as for the proprioceptive system, it is possible to train, for example, to perform specific movements in certain sports, it is also possible to train to improve proprioception following an injury or in certain pathologies such as those resulting from certain injuries of the central nervous system.

Like in any other learning context, brain neuroplasticity is also involved in this balance training process[8,9]. So that the repetition of movements generates new circuits or adaptations in the nervous system, this produces a response base that we can use whenever required10. Factors such as exercising outdoors or with social contact, stimulate the nervous system in its training[11].

Therefore, balance and proprioception could generate this neuroplasticity that is essential in pathologies such as stroke, autism and others. Neuronal plasticity and the importance of sport are already being taken into account in rehabilitation therapies[8,12]. We can therefore highlight the importance of surfing. Currently, the adaptive surfing category exists as a professional sport, showing us that those with some kind of difficulty for practising surfing are able to surf by adapting surfing to their disability. Therefore, it could be thought that surfing could give them a better quality of life related to the development of balance, strength, among others.

The hypothesis of this work was that surfing is an effective stimulus on all those factors underpinning balance. The objective of this study was to evaluate whether the practice of surfing plays a part in the balance and proprioception of athletic subjects, making a comparison between beginner and advanced surfers and with a control group who did not practice sport.

Material and method

This is a correlational/analytical, cross-sectional, descriptive study. All participants gave their consent to participate in the study, and it was approved by the ethics committee of the Universidad Católica of the UCV/2018-2019/110 (Catholic University of Valencia). The entire study complies with the provisions of the Declaration of Helsinki for research involving human subjects. 30 subjects aged from 18 to 30 years of both sexes voluntarily took part in the study, recruited from the "Mediterranean Surf School" in Valencia and "ESSUS" (Surf School) in Zarautz (Guipúzcoa), and university students of Valencia. Of these, 20 individuals were surfers (10 beginners and 10 advanced) and 10 individuals did not practice any sport at all (control group).

The inclusion criteria were: be aged between 18 and 30 years; the control group did not routinely practice sport; the beginner surfers had surfed for 1 year to date; and the advanced surfers for at least 5 years. The exclusion criteria were: taking medication that could affect balance; musculoskeletal injuries that could make it impossible to perform the tests; and disorders affecting balance. In order to evaluate the proprioception of the participants more completely, we conducted a static balance BESS test and a dynamic Y-Balance Test. Due to the fact that different systems are involved in balance and to the difficulty to measure balance as a whole, further tests were conducted in order to evaluate back strength (Biering-Sorensen Test), quadriceps strength (isometric strength- *ChronoJump BoscoSystem*) and flexibility (*Modified-modified Schober Test*) as well as cardiopulmonary strength (Borg Scale) (Figure 1).

The sampling size was determined by the number of volunteers willing to participate in the study. The IBM® SPSS® Statistics version 22 statistical package was used to analyse the results. The graphics design was made with the Microsoft® Excel® 2019 processor. We performed a descriptive analysis of the test results and we studied the mean averages. For the comparative analysis, we used non-parametric tests due to the fact that the sample data were not normally distributed. We studied the relationship of the ranges between the groups and performed a statistical analysis to compare the data of the continuous variables between the different independent groups with the Mann-Whitney U test, taking 5% as the significance level.

Results

The demographic data are shown in Table 1 and Table 2. Data were collected from the 30 participants with a mean age of 22

Table 1. Demographic characteristics of participants.

	N	Mean	Standard deviation
Age			
Control	10	21.7	2.50
Beginner surfer	10	21.6	1.17
Advanced surfer	10	22.6	2.32
Total	30	21.97	2.06
Height (cm)			
Control	10	170.1	11.81
Beginner surfer	10	173.9	7.71
Advanced surfer	10	170.2	9.66
Total	30	171.4	9.69
Weight (kg)			
Control	10	63.75	15.32
Beginner surfer	10	67.84	11.58
Advanced surfer	10	67.07	13.45
Total	30	66.22	13.19

(range: 20-27 years), 10 women and 20 men, with a mean height of 171.4 cm (range: 160-180 cm) and mean weight of 66.22 kg (range: 51-77 kg). 10 subjects did not practice any sport, 10 were beginner surfers and 10 were professional surfers.

The results obtained in the BESS test are provided in Figure 2. The advanced surfers group showed a total of 11.5 errors (9.1 on foam Surface and 2.4 on *firm Surface*), the beginner surfers group showed 12.7 errors (9.6 on *foam Surface* and 3.1 on *firm Surface*) while the control group showed 14.7 errors (11.6 on foam Surface and 3.1 on firm Surface). There were significant differences in the total number of errors between the control group and the advanced surfers group (p= 0.02), in tandem stance on the foam (p=0.01) and the total number of errors on the foam (p=0.03).

The results measured using the Y-Balance Test test are shown in Figure 3. The greatest mean scores were obtained for the Composite Reach Distance (%) in the surfer groups, with a higher score for the

Table 2. Absolute and relative frequencies of questionnaire variables.

	Control		Beginner		Advanced		Total	
Sex	AF	RF	AF	RF	AF	RF	AF	RF
Female	5	0.50	2	0.20	3	0.30	10	0.33
Male	5	0.50	8	0.80	7	0.70	20	0.67
	10	1.00	10	1.00	10	1.00	30	1.00
Location								
Valencia	10	1.00	8	0.80	2	0.20	20	0.67
Zarautz	0	0.00	2	0.20	8	0.80	10	0.33
	10	1	10	1	10	1	30	1
Age								
18-20 years	4	0.4	1	0.1	1	0.1	6	0.2
21-23 years	5	0.5	9	0.9	6	0.6	20	0.6667
24-27 years	1	0.1	0	0	3	0.3	4	0.1333
	10	1	10	1	10	1	30	1
Height								
150-160 cm	2	0.2	1	0.1	2	0.2	5	0.1667
161-170 cm	3	0.3	3	0.3	4	0.4	10	0.3333
171-180 cm	4	0.4	3	0.3	3	0.3	10	0.3333
181-190 cm	1	0.1	3	0.3	1	0.1	5	0.1667
	10	1	10	1	10	1	30	1
Weight								
40-50 Kg	1	0.1	1	0.1	2	0.2	4	0.1333
51-60 Kg	5	0.5	1	0.1	1	0.1	7	0.2333
61-70 Kg	1	0.1	4	0.4	2	0.2	7	0.2333
71-80 Kg	0	0	2	0.2	3	0.3	5	0.1667
81-90 Kg	3	0.3	2	0.2	2	0.2	7	0.2333
	10	1	10	1	10	1	30	1
Dominance								
Right	5	0.5	10	1	8	0.8	23	0.7667
Left	5	0.5	0	0	2	0.2	7	0.2333
	10	1	10	1	10	1	30	1
Smokers								
No	9	0,9	8	0,8	8	0,8	25	0,8333
Yes	1	0,1	2	0,2	2	0,2	5	0,1667
	10	1	10	1	10	1	30	1
Years/Smoking								
No	9	0.9	8	0.8	8	0.8	25	0.8333
Yes	1	0.1	2	0.2	2	0.2	5	0.1667
	10	1	10	1	10	1	30	1
Sport								
No	2	0.2	0	0	1	0.1	3	0.1
Yes	8	0.8	10	1	9	0.9	27	0.9
	10	1	10	1	10	1	30	1

Figure 1. A) Bess Test. B) YBT Test. C) *ChronoJump.*

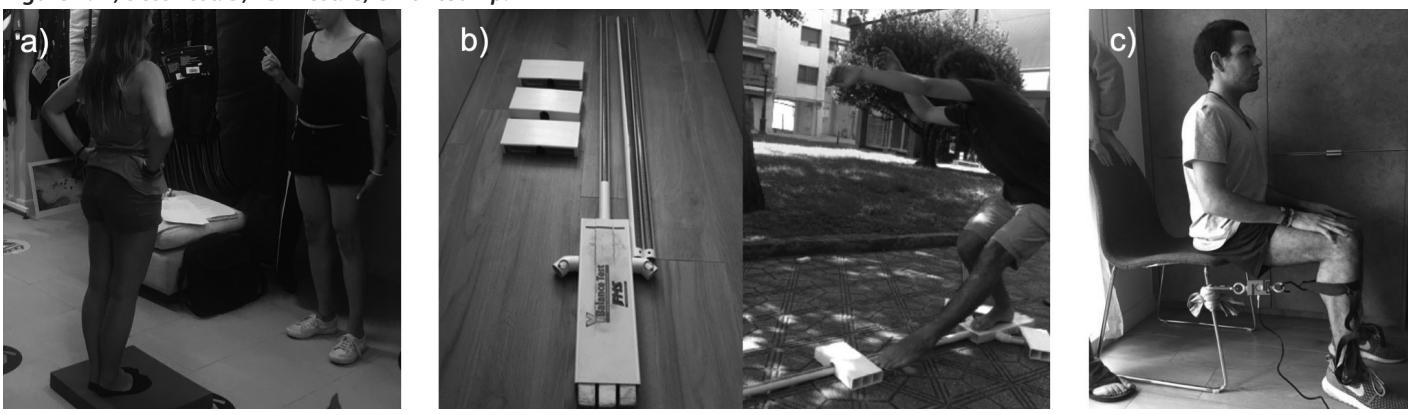


Figure 2. Comparison or number of errors between a firm and unstable surface. BESS Test

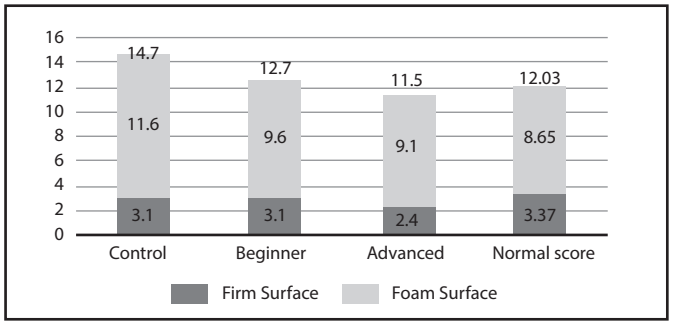
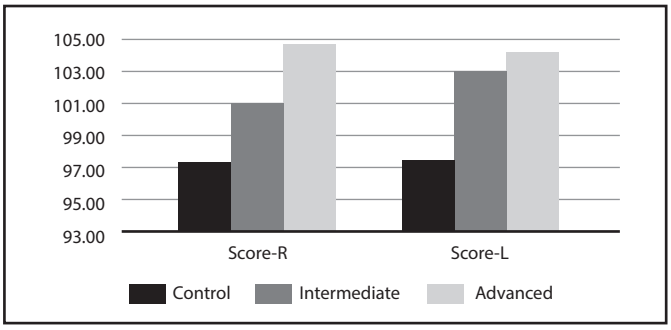


Figure 3. YBT comparison of Scores between right and left legs between the groups.



R: *Right;* L: *Left.*

Figure 4. BST comparison of groups at 1st, 2nd attempt, mean and the difference between the 1st and 2nd attempt.

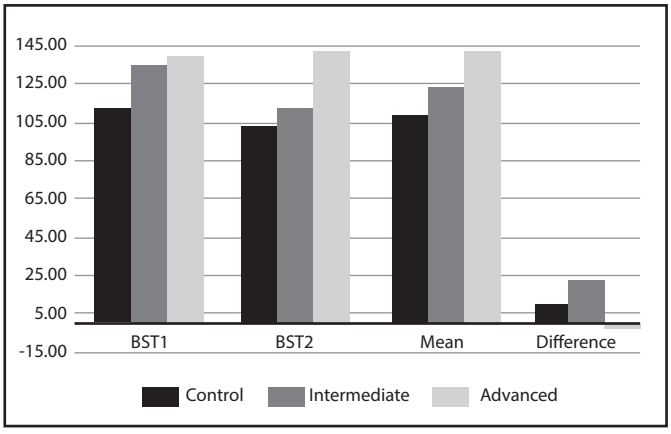
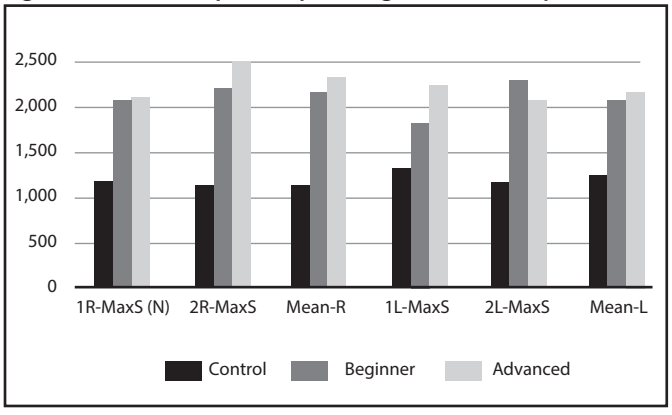


Figure 5. Maximum quadriceps strength *(ChronoJump).*



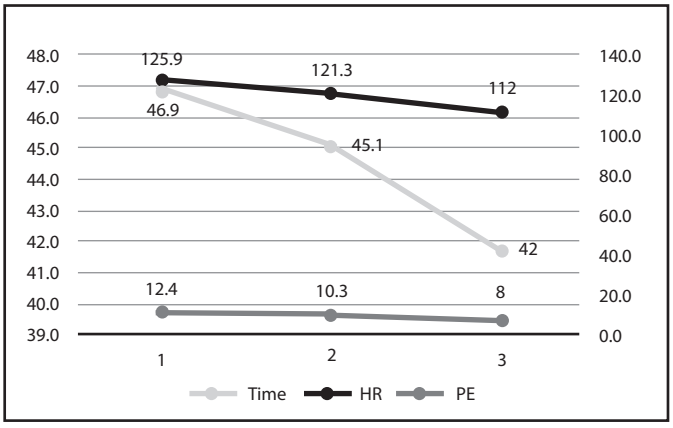
R: *Right*, L: *Left*; MaxS: maximum strength; 1: first attempt; 2: Second attempt: N: Newtons.

advanced surfers. Significant differences were observed in the comparison between advanced surfers and non-surfers, in two of the directions with the right leg, the posteromedial (p= 0.03) and the posterolateral (p= 0.03). When comparing beginner surfers with non-surfers, significant differences were obtained in the posteromedial direction, for both the right leg (p= 0.03) and the left one (p= 0.001), and in the posterolateral direction with the right leg (p= 0.017).

The results measured using the Biering-Sorensen Test are shown in Figure 4. We observed for the advanced surfers an increase in the mean time in the study stance of the second attempt in relation to the first, as well as a greater mean time in both attempts compared to the beginner surfers and non-surfers.

In the descriptive analysis of the maximal isometric quadriceps strength test (Figure 5), it can be seen how the mean strengths of the

Figure 6. Borg Test with the means for frequency after completing the circuit.



1: Control; 2: Beginner; 3: Advanced; HR: heart rate; PE: Perceived effort.

control group remained below those of the surfer groups. Significant differences were observed when comparing the results of the attempts of the control group with the right foot, with the beginner surfer group ($p<0.05$) and advanced surfers ($p<0.05$); and the second attempt with the left leg, when comparing these same groups ($p<0.05$).

Finally, in the comparative analysis of the Borg test (Figure 6), significant differences were observed in the perceived effort scale when comparing non-surfers with advanced surfers ($p=0.008$). We also observed significant differences in the heart rate after completing the circuit for the first time and the minute of rest for non-surfers ($p=0.02$) and beginner surfers ($p=0.03$) in relation to the advanced surfers, who exhibited lower values.

Discussion

For the BESS test, we obtained significant differences that reflect better results for the group of advanced surfers compared to the beginner and control groups, both for the foam testing surface and for total errors. This leads us to think that, with increased balance demands, on an unstable surface and without the visual system, advanced surfers have better postural control and intrinsic proprioception. There were no significant differences between the control group and the beginner group. This could be due to the fact that they were performing this exercise for the first time. For future studies, it could be of interest to test whether, following a minimum practice time, the difference in errors increases, as well as the influence of the visual system by repeating the exercise with the subject's eyes open, given that other studies have obtained different results by varying the state of this sensitive system[3,5]. It could also be of interest to observe the variations in balance between groups when having to concentrate on another mental task.. When comparing advanced surfers with swimmers, Chapman *et al*.[5] concluded that when a balance test was performed together with another cognitive test, expert surfers adapted their posture more easily. The participant who obtained less errors (5 errors) in this test, had an extremely advanced slackline level. To the best of our knowledge, there is no prior literature in which this test has been used on surfers.

The dynamic balance was evaluated with the Y-Balance Test, a test that requires strength, flexibility, neuromuscular control and proprioception, which are characteristics that play a part in balance[13]. Neither has this test been previously used on surfers to evaluate balance. However, a study in which the YBT test was conducted on football players recorded a mean Composite Reach Distance (%) for amateur football players (98.8±9.2%, left; 99.2±8.8%, right) and professionals (96.9±8%, left; 98.5±8.5%, right) that was less than that recorded in this study for beginner surfers (103% left; 101.1% right) and advanced surfers (104.3% left; 104.8% right)[14]. The same thing happens when comparing the results with another study on healthy young adults[13,14].

The Modified-Modified Schober Test was used to measure the flexibility of surfers and non-surfers, finding no significant differences. With regard to the mean, we could interpret the reduction in the average for the beginner group as the result of overexertion in the first attempt, leading to exhaustion or discomfort in the hamstrings, antagonist hip flexor muscles. Renneker *et al.*[1] described a limited flexibility of the shoulder, back and hamstrings of surfers. Prior literature indicates that flexibility may be reduced as a result of the repetition of movements and intense training, although back pain may also be a factor related to the above[14,15]. In our study, no subject suffered from lumbago at the time of the tests, given that this was included in the exclusion criteria.

We have found no studies that evaluate the back strength of surfers. We considered the Biering-Sorensen Test (BST) to be a suitable test to measure back strength and resistance. Despite the fact that no significant differences were obtained between groups, when the mean averages were compared we observed that the advanced surfers had greater back strength and resistance, slightly increasing from one attempt to the next with a mean time of 140 seconds, while for the control group (107 seconds) and the beginners group (123 seconds) the mean duration is lower with a decreasing slope.

During the test, the participants were asked about the site where they first noticed fatigue, the control group referred to the back area while the surfers indicated the gluteus.

Due to the novelty of the Chrono-Jump programme and the lack of articles using this test, of all the variable provided by this programme, we decided to use only the maximum strength. This evaluation is of interest given that it "is valid in evaluating the influence of strength on dynamic performance"[16]. We obtained a higher maximum strength for the surfers. The literature consulted highlights the importance and the development of the quadriceps musculature when surfing the waves as well as its benefit on balance[3,7].

Finally, for the Borg test, when comparing the means, we reached the conclusion that cardiovascular capacity improves as the surfer becomes more skilled. Surfers considered exercise to be light or very light while non-surfers considered it to be hard or very hard. Prior literature also supports the idea that the practice of surfing improves cardiopulmonary resistance[17-19].

Therefore, surfing could be a sport with great potential in the field of rehabilitation. Furthermore, the improvements demonstrated in psychological studies may help to achieve more effective rehabilitation.

And not only could surfing be included, but a study could be made of the exercises used in training in order to include them in rehabilitation programmes[20].

In conclusion, surfers obtained better results in the balance tests evaluated, on the foam pad in the BESS test and in some of the YBT directions. Likewise, surfers exhibited greater back strength and quadriceps strength, which are essential muscles to maintain balance and stance. Finally, surfers exhibited a greater tolerance to effort, evaluated using the Borg scale.

Conflict of interest

The authors have no conflict of interest at all.

Bibliography

1. Renneker M. Surfing: The Sport and the Life-Style. *Phys Sportsmed.* 1987;15(10):156–62.
2. Furness JW, Hing WA, Sheppard JM, Newcomer SC, Schram BL, Climstein M. Physiological Profile of Male Competitive and Recreational Surfers. *J Strength Cond Res*. 2018 Feb;32(2):372-378.
3. Bruton MR, O'Dwyer NJ, Adams RD. Neuromuscular characteristics of recreational and competitive male and female surfers. *Int J Perform Anal Sport.* 2013;13(2):388-402.
4. Winter DA, Patla AE, Frank JS. Assessment of balance control in humans. *Med Prog Technol.* 1990;16(1–2):31–51.
5. Chapman DW, Needham KJ, Allison GT, Lay B, Edwards DJ. Effects of experience in a dynamic environment on postural control. *Br J Sports Med.* 2008;42(1):16–21.
6. Tarantino Ruiz F. Propiocepción. Introducción teórica. EFisioterapia. 2010;5.
7. Secomb JL, Farley ORL, Lundgren L, Tran TT, King A, Nimphius S, *et al.* Associations between the performance of scoring manoeuvres and lower-body strength and power in elite surfers. *Int J Sport Sci Coach*. 2015;10(5):911–8.
8. Seidel O, Carius D, Kenville R, Ragert P. Motor learning in a complex balance task and associated neuroplasticity: a comparison between endurance athletes and nonathletes. *J Neurophysiol*. 2017;118(3):1849–60.
9. McDonnell MN, Buckley JD, Opie GM, Ridding MC, Semmler JG. A single bout of aerobic exercise promotes motor cortical neuroplasticity. *J Appl Physiol*. 2013;114(9):1174–82.
10. Cuadrado EF. 10o Congreso Argentino y 5o Latinoamericano de Educación Física y Ciencias. *Elsevier Connect*. 1995;(2012):1–16.
11. Hötting K, Röder B. Beneficial effects of physical exercise on neuroplasticity and cognition. *Neurosci Biobehav Rev.* 2013;37(9):2243–57.
12. Hirsch MA, Farley BG. Exercise and neuroplasticity in persons living with Parkinson's disease. *Eur J Phys Rehabil Med*. 2009;45(2):215–29.
13. Alnahdi AH, Alderaa AA, Aldali AZ, Alsobayel H. Reference values for the y balance test and the lower extremity functional scale in young healthy adults. *J Phys Ther Sci.* 2015;27(12):3917–21.
14. Coorevits P, Danneels L, Cambier D, Ramon H, Vanderstraeten G. Assessment of the validity of the Biering-Sørensen test for measuring back muscle fatigue based on EMG median frequency characteristics of back and hip muscles. *J Electromyogr Kinesiol.* 2008;18(6):997-1005.
15. Bazanella NV, Garrett JGZD, Gomes ARS, Novack LF, Osiecki R, Korelo RIG. Associação entre dor lombar e aspectos cinético-funcionais em surfistas: incapacidade, funcionalidade, flexibilidade, amplitude de movimento e ângulo da coluna torácica e lombar. *Fisioter e Pesqui.* 2016;23(4):394–401.
16. Secomb JL, Nimphius S, Farley ORL, Lundgren L, Tran TT, Sheppard JM. Lower-body muscle structure and jump performance of stronger and weaker surfing athletes. *Int J Sports Physiol Perform.* 2016;11(5):652–7.
17. Meir RA, Lowdon BJ, Davie AJ. Heart rates and estimated energy expenditure during recreational surfing. *Aust J Sci Med Sport.* 1991;23(3):70–4.
18. Armitano CN, Clapham ED, Lamont LS, Audette JG. Benefits of Surfing for Children with Disabilities: A Pilot Study. *Palaestra*. 2015;29(3):31–4.
19. Clapham ED, Lamont LS, Shim M, Lateef S, Armitano CN. Effectiveness of surf therapy for children with disabilities. *Disabil Health J.* 2020;13(1).
20. Fleischmann D, Michalewicz B, Stedje-Larsen E, Neff J, Murphy J, Browning K, *et al*. Surf medicine: Surfing as a means of therapy for combat-related polytrauma. *J Prosthetics Orthot*. 2011;23(1):27–9.

POSTGRADOS OFICIALES:
SALUD Y DEPORTE

UCAM
UNIVERSIDAD
CATÓLICA DE MURCIA

- **Actividad Física Terapéutica** *(2)*
- **Alto Rendimiento Deportivo: Fuerza y Acondicionamiento Físico** *(2)*
- **Performance Sport: Strength and Conditioning** *(1)*
- **Audiología** *(2)*
- **Balneoterapia e Hidroterapia** *(1)*
- **Desarrollos Avanzados de Oncología Personalizada Multidisciplinar** *(1)*
- **Enfermería de Salud Laboral** *(2)*
- **Enfermería de Urgencias, Emergencias y Cuidados Especiales** *(1)*
- **Fisioterapia en el Deporte** *(1)*
- **Geriatría y Gerontología: Atención a la dependencia** *(2)*
- **Gestión y Planificación de Servicios Sanitarios** *(2)*
- **Gestión Integral del Riesgo Cardiovascular** *(2)*
- **Ingeniería Biomédica** *(1)*
- **Investigación en Ciencias Sociosanitarias** *(2)*
- **Investigación en Educación Física y Salud** *(2)*
- **Neuro-Rehabilitación** *(1)*
- **Nutrición Clínica** *(1)*
- **Nutrición y Seguridad Alimentaria** *(2)*
- **Nutrición en la Actividad Física y Deporte** *(1)*
- **Osteopatía y Terapia Manual** *(2)*
- **Patología Molecular Humana** *(2)*
- **Psicología General Sanitaria** *(1)*

(1) Presencial *(2) Semipresencial*

MÁS INFORMACIÓN: **968 27 88 01** · **ucam.edu**